EARLY CHANGES IN GRADATION STYLES AND RATES ON MARS P. H. Schultz and D. Britt, Brown University, Dept. of Geological Sciences, Box 1846, Providence, RI 02912

INTRODUCTION: The history of an active surface-atmosphere exchange of volatiles on Mars is recorded in the ancient cratered terrains. Large impact basins and craters provide a means to document this process and any changes in style with time. Two large impact basins (Isidis and Argyre) produced large well-defined geologic units and terrains, thereby allowing reliable crater statistics and dentification of time-dependent processes prior to most well-perserved volcanic events. Moreover, the collective impact basin record permits calibration of ancient gradation rates.

APPROACH: The wide annulus of massifs and knobs of Isidis and Argyre provided sufficiently large areas for meaningful crater statistics of large (>30km diameter) craters. Counts were made over adjacent and nested areas in order to test consistency and to derive relative ages of each basin. Within the Isidis annulus, characteristic terrains provided counting areas for dating contrasting surface process: channeled hummocky terrain, etched terrains, and intermassif channeled plains. The channeled hummocky terrain contains a high channel density (length/area) of narrow valley networks cutting both primary Isidis features and old craters. The etched terrains represent a broad region outside the inner high-relief massifs of southwestern Isidis where numerous irregular plateaus, mesas, and relict craters indicate a different style of erosion. The intermassif channeled plains occur along the inner mountainous ring. Shallow meandering channels form a large integrated drainage system that is linked to numerous smaller intermountain basins ("ponds"). These ponds and interconnected tributaries extend beyond the primary inner massif ring through broad canyons.

The Argyre basin presents a dramatic contrast in channel development. Deeply incised, narrow valleys exist but emerge along the scarp or are highly localized. Intermassif plains contain subtle curvilinear channels but the high density networks and furrowed massifs typical for Isidis are missing (1,2). To the south, long curvilinear channels and canyons follow heavily degraded basin structure and topography from beyond the Argyre scarp to the interior where narrow ridges appear to replace the original channel course. Narrow-valleys on ejecta facies superposing Argyre are isolated and unlike the systems within Isidis. Crater statistics have been obtained for the knobby terrain inside the scarp where larger post-terrain craters could not be buried by plains.

Figure 1 and Table I summarizes selected data from this study and permits comparison with other published crater counts of major volcanic events (3). Both the Isidis and Argyre crater distributions contrast with distributions derived for the oldest plains units examined here and elsewhere (4). A rapid fall-off in the number of craters smaller than 20km in diameter may reflect a different production population, enlargement of craters by erosion (¬25%), or a basin secondary crater population (10-50km in diameter). Each possibility is being explored in more detail but we tentatively believe that the distribution curves are indicating active gradational processes since the formation of Isidis and Argyre. The observed crater distribution of Sinai Planum has been used as a "standard" in order to correct for crater loss of ancient terrains and to extend data from small counting areas. These counts have been normalized to $10km/10^6 km^2$ in order to minimize the amount of extrapolations from either ancient or recent terrains.

DISCUSSION: The change in narrow-valley-network (nvn) drainage density within well-defined drainage basins and the change in style with time is shown in Figure 1. As discussed previously (2,5), a rapid change is indicated after the Argyre impact. This can be documented not only by comparison between Isidis and Argyre but also by old impact craters. Four conclusions emerge. First, the interior massif/knobby annulus of Argyre does not appear to be a pristine basin surface but a modified terrain dating from early volcanic plains emplacement. The terrain is similar to but later than the knobby terrains of Elysium, which may be related to an ancient

modified basin (6). Second, much later channel development is observed within the Isidis intermassif region. These channels form a long, relatively mature and integrated system. Third, both the etched terrains within Isidis and the nearby volcanic plains of Syrtis Major Planitia date from approximately the same period. Fourth, late-stage (comparable in age to Syrtis Major Planitia) unintegrated run-off channel systems occur within the mantled ejecta facies of old impact craters or are localized in certain deposits/terrains.

These results provide quantitative data for the change in gradation with time on Mars. Prior to the Argyre impact, the formation of narrow valley networks within Isidis resulted in removal of 75% of the crater smaller than 3km in diameter and 30% of craters smaller than 10km and/or 10-25% enlargement of larger craters. The size distribution of large martian impact basins in the ancient cratered terrains suggests broader scale losses during earlier epochs, rather than an absence of basin-forming impactors. The knobby terrain of the Elysium region and the nearby fretted terrain margins developed after the formation of Argyre, at about the time of the earliest volcanic constructs were formed. This process, and presumably the formation of the martian "dichotemy" appears to reflect on erosional event (rather than, or in addition to a tectonic process). The knobby terrains within Argyre may preserve a similar process nearly simultaneous with early volcanic plains emplacement (Sinai Planum). The etched terrains that apparently are associated with the emplacement of Syrtis Major Planitia of southern Isidis may represent an arrested analog for this process. Narrow-valley network formation apparently had ceased except as highly localized occurrences reflecting geothermal activity or emergent springs. The dramatic change in broad-scale gradation rates and style from pre-Argyre to Tharsis times suggest a change from atmosphere-surface exchange to principally surface/subsurface volatile loss including water and perhaps trapped carbonates (7).

References: (1) Schultz, P.H. and Rogers, J. (1982) *Conf. on Planetary Volatiles*, LPI Contrib. 488, p. 97-98. (2) Schultz, P.H. *et al.* (1984), LPI Tech Report 85-03 (S. Clifford, ed), p. 82-84. (3) Plescia, J.B. and Saunders, R.S. (1979) *Proc. Lunar Planet. Sci. Conf. 10th*, p. 2841-2859. (4) Neukum, G. and Wise, D. (1976) *Conf. on Evolution of the Martian Atmosphere*, Lunar and Planetary Institute, Houston. (6) Schultz, P.H. (1984) *Lunar and Planetary Science XV*, p. 728-729, Lunar and Planetary Institute, Houston. (7) Kahn, R. (1985) *Icarus*, *62*, 175-190.

Feature/Unit +	Log N(>10Km)/10^6km^2 *	Channel Density (km/km^2)	Channel Style
Hellas (B)	3.1		valley networks
Isidis (B)	3.0	10^{-1}	valley networks
Uranius Tholus (V)	2.9		channeled
Argyre (B)	2.68	$<2x10^{-2}$	localized networks
Ulysses Patera (V)	2.62		
Nepenthes Mensae (KT)	2.29		
Elysium Knobby terrain	2.29		
Tharsis Tholus (V)	2.25		
Argyre-massif annulus (KT)	1.98		run-off;emergent
Apollonaris Patera (V)	1.95		channeled
Uranius Patera (V)	1.95		
Tyrrhena Patera	1.93		channeled
Sinae Planum (VP)	1.90		
Syrtis Major Dy (C)	1.85	$2x10^{-2}$	isolated run-off
Hesperia Planum (VP)	1.83		
Cerulli	1.83		isolated run-off
Isidis-intermassif (ChP)	1.75		integrated run-off
Syrtis Major Planitia	1.75		
Peridier (C)	1.71	$<2x10^{-2}$	isolated run-off
Lunae Planum (VP)	1.55		
Holden (C)	1.55		

+ B = basin; C = impact crater; V = volcanic construct; KT = knobby terrain; VP = volcanic plain; ChP = channeled plains.

* adjusted using crater statistics for Sinae Planum

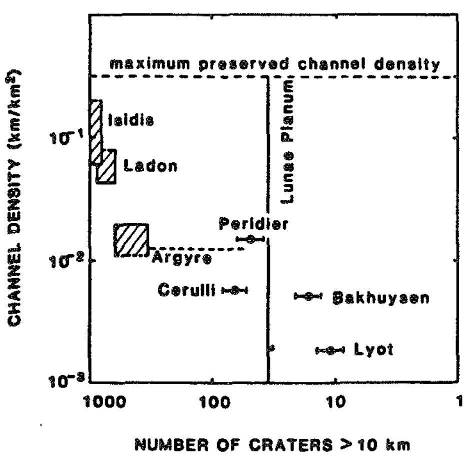

Figure 1. Production rate of narrow valley formation on selected basins and craters indicated by channel density (length/area) and superposed crater density (number > 10km/10^6km^2).